

DRAFT Woundfin (*Plagopterus argentissimus*) Thermal Tolerance Analyses – Juvenile and Adult, Summer
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Introduction

Recommended summer chronic and acute thermal tolerance values for juvenile and adult woundfin and their justification are discussed below. The recommended tolerance values were developed in accordance with the “*DRAFT Methodology for Developing Thermal Tolerance Thresholds for Various Fish in Nevada – Juvenile and Adult, Summer*” (September 2015).

Chronic Thermal Tolerance Thresholds

Table 1 provides a summary of the range of chronic temperature tolerance values for woundfin for various lines of evidence. These values are based upon a review of 4 papers and publications, the details of which are summarized in Attachment A. There is obviously a wide range of temperatures from which to select an appropriate value and best professional judgment is called for. NDEP’s approach is to accept the EPA recommendations from Brungs and Jones (1977) unless the literature review provides a compelling reason to utilize other values. However, in the case of the woundfin, EPA has not recommended a chronic thermal tolerance value.

It is recommended that a chronic temperature tolerance value of 26°C be used for woundfin. This value is at the upper end of the reported optimal growth study results. As discussed in the methodology, chronic temperature criteria are generally not set to ensure the most optimum conditions. In fact, Brungs and Jones (1977) recommends that the chronic criterion for a given fish species be between the optimum temperature and the UUILT.

Table 1. Summary of Chronic Temperature Tolerances

Category	Temperature (°C)
Laboratory Optimal Growth Studies – Constant Temperature	
Optimum	23.4
Upper Optimum	26
Laboratory Temperature Preference Studies	
Average Preferences	11 – 24
Upper Preferences	20 – 32
Final Preferendum	19.5
Field Studies	10 – 35.5
Recommended Chronic Temperature Tolerance (MWAT)	26

Acute Thermal Tolerance Thresholds

Table 2 provides a summary of the range of acute temperature tolerance values for woundfin for various lines of evidence. These values are based upon a review of 4 papers and publications, the details of which are summarized in Attachment B.

For ease of presentation, the UILT and CTM values have been summarized by acclimation temperature ranges. As discussed in the methodology document, only the UILT and CTM values for acclimation temperature near the recommended chronic criterion (26°C) should to be included in the acute criterion development process. However for woundfin, there are limited acute test results available for acclimation temperatures of 26°C. Therefore, it was appropriate to consider other acclimation temperature results in the analysis.

Table 2. Summary of Acute Temperature Tolerances

Category	Temperature Tolerances (°C)	Potential Acute Criteria (°C)
Laboratory Lethal Studies – UILT		
Acclim. = 21.5°C	34.5	>32.5 ¹
Laboratory Lethal Studies – CTM		
Acclim. = 10°C	30.7	
Acclim. = 15°C	33.6	
Acclim. = 25°C	39.5	35.5 ²
Other Acute Studies – Agitated Behavior		
Acclim. = 21.1°C	32.5	
Acclim. = 23.9°C	33.3	<33.3 – 34.7 ³
Acclim. = 29.4°C	34.7	
Other Acute Studies – Varying Mortality Rates		
Acclim. = 23°C – 0% mortality	31	>31 ⁴
Acclim. = 23°C – 16% mortality	32	
Acclim. = 23°C – 30% mortality	33.5	
Recommended Acute Temperature Tolerance (MDMT)		33

¹UILT and UUILT values reduced by 2°C to provide 100% survival (See *Methodology*). The available tests were for acclimation levels (21.5°C) less than the recommended chronic criterion (26°C). Since thermal tolerances typically increase with increasing acclimation levels, these test results represent a thermal threshold less than expected for a higher acclimation temperature of 26°C.

²CTM values reduced by 2°C to estimate quasi-UILT values. Quasi-UILT value then reduced by 2°C to provide 100% survival (See *Methodology*)

³Non-traditional acute tests suggest criteria should be lower than this level to avoid agitated behavior.

⁴Non-traditional acute tests suggest the highest allowable temperature with no mortality is around 31°C. However, these results are for a lower acclimation level ((23°C) less than the recommended chronic criterion (26°C). Since thermal tolerances typically increase with increasing acclimation levels, these test results represent a thermal threshold less than expected for a higher acclimation temperature of 26°C.

A review of laboratory studies suggests that an appropriate acute criterion should fall between 31 and 35.5°C. NDEP's approach is to accept the EPA recommendations from Brungs and Jones (1977) unless the literature review provides a compelling reason to utilize another value. However in the case of the woundfin, no such recommendations are available and best professional judgment is needed. An acute thermal tolerance of 33°C is recommended as this value falls within the range suggested by the literature.

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References

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ATTACHMENT A

Detailed Summary of Chronic Thermal Tolerance Values for Woundfin, Juvenile and Adult, Summer

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Table A-1. Chronic Temperature Tolerances – Laboratory Optimal Growth Studies – Constant Temperature

Reference	Age or Size	Acclim. Temp. (°C)	Optimum Growth Temperature		Upper Optimum Growth Temperature	
			Temp. (°C)	Comment	Temp. (°C)	Comment
Addley et al. (2005)	49-75 mm, 0.93-3.64 g	4.4 – 32.2	23.4		26	Estimated temperature at growth rate = 80% of optimum

Table A-2. Chronic Temperature Tolerances – Laboratory Preference Studies

Reference	Age or Size	Acclim. Temp. (°C)	Average Preference Temperature		Upper Preference Temperature		Final Preferendum	
			Temp. (°C)	Comment	Temp. (°C)	Comment	Temp. (°C)	Comment
Deacon et al. (1987) ¹	Juvenile, adult	10	11	Average preference	20	Highest temperature occupied	19.5	
		15	16	Average preference	23	Highest temperature occupied		
		25	24	Average preference	32	Highest temperature occupied		

¹Fish collected from Virgin River system – Utah, Arizona, Nevada

Table A-2. Chronic Temperature Tolerances – Field Studies

Reference	Temperature (°C)	Comments
Cross (1978)	10.0 – 35.5	Fish found in water temperatures ranging from 10.0 to 35.5 °C
Lockhart (1977)	30	Lockhart (1977) reported that when water temperatures approach 30°C, woundfin leave shallow water areas and congregate in the deeper, cooler portions of streams.

ATTACHMENT B

Detailed Summary of Acute Thermal Tolerance Values for Woundfin, Juvenile and Adult, Summer

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Table B-1. Acute Temperature Tolerances – Laboratory Lethal Temperatures, UILT/UUILT

Reference	Size or Age	Acclim. Temp. (°C)	Test Duration	UILT		UUILT	
				Temp. (°C)	Comment	Temp. (°C)	Comment
Lockhart (undated)	Unknown	21.5	Unknown	34.5			

Table B-2. Acute Temperature Tolerances – Laboratory Lethal Temperatures, Critical Thermal Maximum

Reference	Size or Age	Acclim. Temp. (°C)	Rate	Temperature (°C)	Endpoint
Deacon et al. (1987) ¹	Juvenile, adult	10	0.24°C/min (14.4°C/hour)	30.7	Loss of equilibrium
		15		33.6	
		25		39.5	

¹Fish collected from Virgin River system – Utah, Arizona, and Nevada

Table B-3. Acute Temperature Tolerances – Other Acute Studies

Reference	Acclim. Temp. (°C)	Temperature (°C)	Comments
Addley et al. (2005)	32.4	32.4	The maximum acclimation temperature that woundfin could survive for a week was 32.4°C
	21.1	32.5	Based upon linear regression, acute observable stress for fish was observed
	23.9	33.3	
	29.4	34.7	
Williams (1992)	23	31	0% mortality – 5 days of fluctuating temperatures from 23 to 31°C
		32	16% mortality – 5 days of fluctuating temperatures from 23 to 32°C
		33.5	30% mortality – 5 days of fluctuating temperatures from 23 to 33.5°C